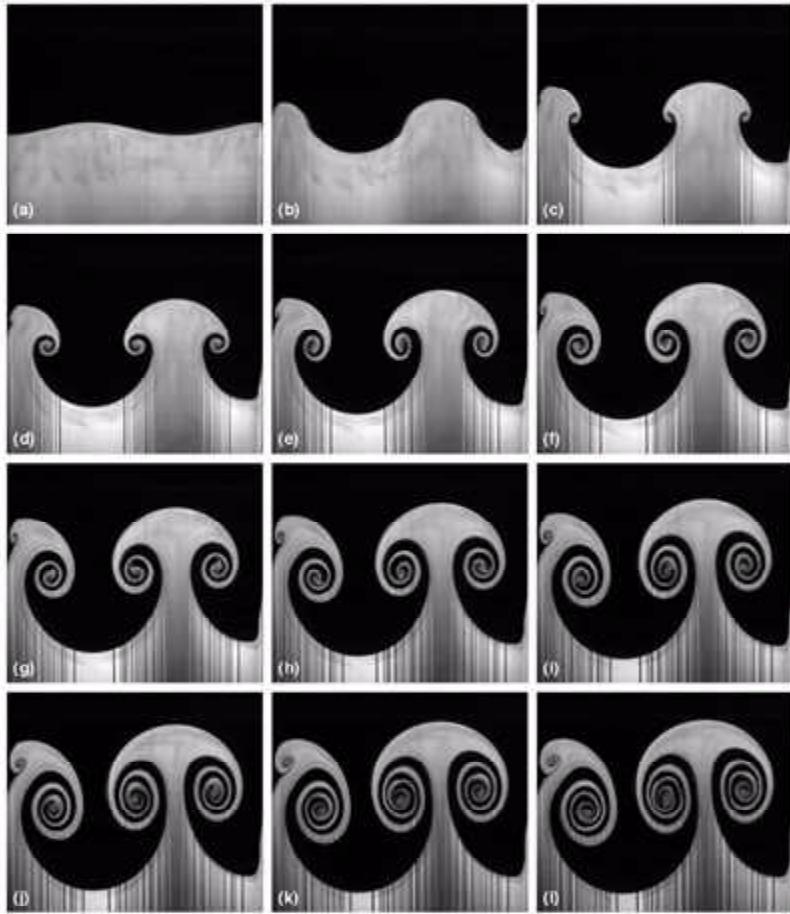


Two-Fluid Interface Instability Being Studied

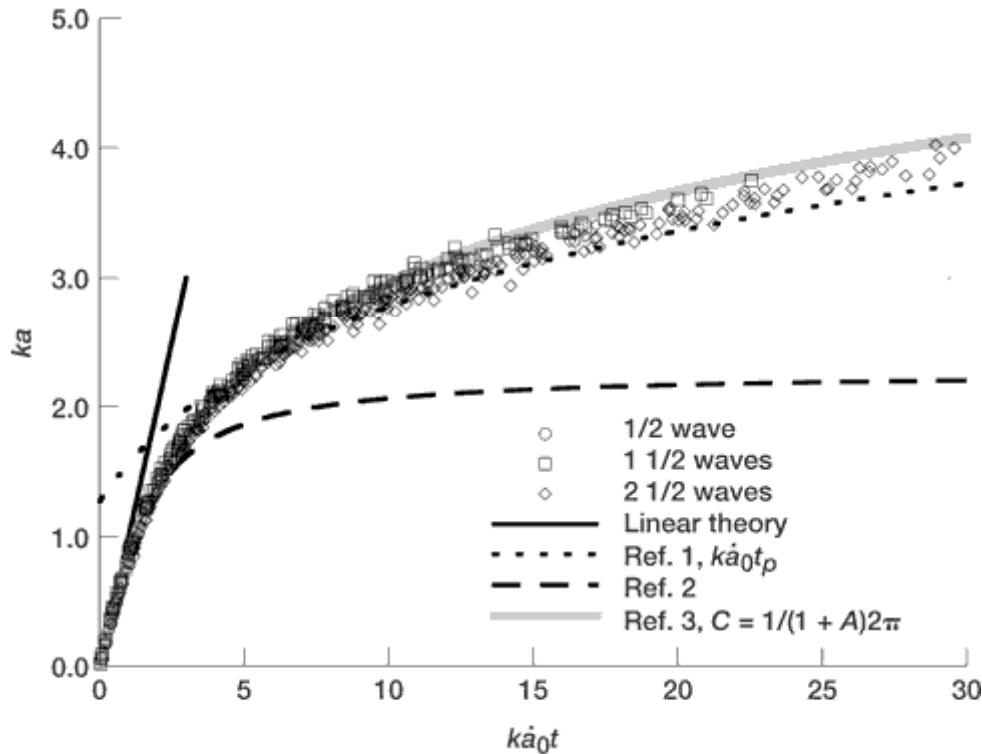
The interface between two fluids of different density can experience instability when gravity acts normal to the surface. The relatively well known Rayleigh-Taylor (RT) instability results when the gravity is constant with a heavy fluid over a light fluid. An impulsive acceleration applied to the fluids results in the Richtmyer-Meshkov (RM) instability. The RM instability occurs regardless of the relative orientation of the heavy and light fluids. In many systems, the passing of a shock wave through the interface provides the impulsive acceleration. Both the RT and RM instabilities result in mixing at the interface. These instabilities arise in a diverse array of circumstances, including supernovas, oceans, supersonic combustion, and inertial confinement fusion (ICF). The area with the greatest current interest in RT and RM instabilities is ICF, which is an attempt to produce fusion energy for nuclear reactors from BB-sized pellets of deuterium and tritium. In the ICF experiments conducted so far, RM and RT instabilities have prevented the generation of net-positive energy. The \$4 billion National Ignition Facility at Lawrence Livermore National Laboratory is being constructed to study these instabilities and to attempt to achieve net-positive yield in an ICF experiment.

The NASA Glenn Research Center, in collaboration with Dr. Jeff Jacobs at the University of Arizona, has been studying RM instability with novel incompressible liquid-liquid experiments. Whereas ICF RM experiments are only a millimeter in size or smaller with time scales of nanoseconds and shock-tube RM experiments are centimeters in size with time scales of milliseconds, these liquid-liquid RM experiments occurred across a container width of 12 cm and a time of nearly 1 s. These experiments have allowed for much better visualization of the instability and have provided needed insight into the initial stages of the instability and its transition to turbulence. The experiments were conducted in a 3-m drop tower at the University of Arizona, with the impulsive acceleration provided by bouncing the fluid-filled container off of a retractable spring. The subsequent free fall as the experiment traveled in the drop tower allowed the instability to evolve in effective absence of the Earth's gravity.



Sequence of images from an experiment with 1 1/2 waves and $ka_i = 0.23$. Times are relative to the midpoint of spring impact. (a) -14 ms. (b) 102 ms. (c) 186 ms. (d) 269 ms. (e) 353 ms. (f) 436 ms. (g) 529 ms. (h) 603 ms. (i) 686 ms. (j) 770 ms. (k) 853 ms. (l) 903 ms.

The preceding figure is a sequence of planar, laser-induced fluorescence (PLIF) images showing the evolution of the RM instability. The instability is generated from a small-amplitude sinusoidal perturbation with an initial nondimensional amplitude ka_i of 0.23 and 1½ waves inside the experiment tank. The direction of the acceleration in this case causes the perturbation to invert before growing, eventually forming a row of vortices of alternating sign. The peak amplitude is compared with various analytical models in the following graph. The experiments are in excellent agreement with linear stability theory at small amplitudes and with a vortex model developed in reference 1 after the vortices have fully developed. The amplitude was nearly independent of the Reynolds number Re on the basis of the (calculated) circulation of a vortex. However, the vortex evolution was a function of Re . A secondary instability of the vortex cores has also been observed, with the time to instability appearance proportional to $Re^{-1/2}$. A new apparatus is under construction that will operate in Glenn's 2.2-Second Drop Tower, more than doubling the observation time of the instability, in an effort to study the transition to a turbulent flow.



Plot of nondimensional amplitude ka versus nondimensional time $k_0 t$ data along with curves from several theories.

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